>Paper ID <

A Statistical Modeling based System for Blink Detection in Digital Cameras

Peter Corcoran, Ioana Bacivarov, Mircea C. Ionita
Department of Electronic Engineering, NUI Galway, Ireland

***Abstract*—We describe in this paper a system which uses statistical eyes modeling to track the eyes and detect eyes blinking. The main challenge was to design an eye model robust to small variations of head pose and to identify the parameters of the model with encode the variation caused by blinking.**

I.INTRODUCTION

Being one of the significant features of the human face, eyes play an important role in a large area of consumer-oriented applications, like facial expression analysis [1], computer animation [2], [3], driver awareness systems [4], [8], film and advertising industry [7] or assisting people with disability by eye-based communication interface [5], [6]. In consequence, eye-related applications have received a great deal of attention lately.

However, current eye models function well for open eyes, the main challenge being physiological needs for humans as blinking. Determining eye states (i.e. open or closed) is more difficult than just determining eye locations. Because of their small region occupancy on the face, minor color information or weak contrast between the eye and the surrounding skin are encountered.

In our article, a model for the eye region area is constructed, using the active appearance aodel (AAM) techniques [9], having as main target the extraction of the eye blinking parameters. Using this information, a blink detector is developed. To our knowledge, the AAM was not used yet to model the eye blinking. It has been used though by D. W. Hansen et. all [10], to model the eye region for gaze tracking, but their method cannot be employed in its current setting for blinking eyes.

II. MODEL DESCRIPTION

The appearance of the eye region is represented by a statistical model trained using a set of annotated image examples. The training set contains faces with eyes open and closed, the model being able to synthesize all the states in between. A new image can be interpreted by finding the best plausible match of the model to the image data. The way in which the annotation was performed is shown in Fig. 1.

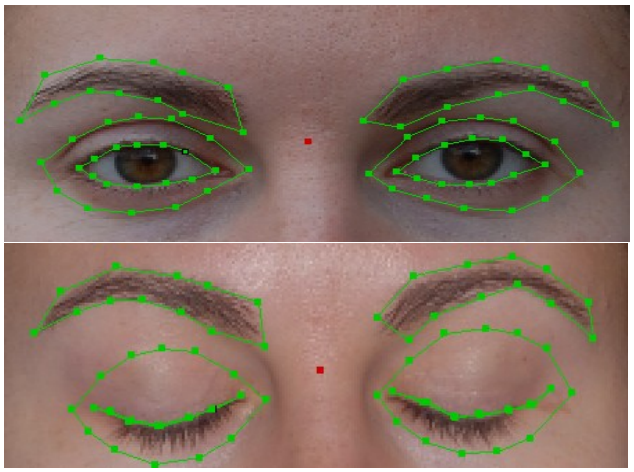

Fig. 1. Image annotations for open and closed eyes.

One significant goal for the model is the extraction of the model parameters that encode the eye blinking information. The blinking uses mainly shape information (the eyelid is modifying its shape between the two states). Depending in a small extend on the complexity of the training set, the shape parameters can be differentiated between closed/open eyes parameters and shape-of-the-eye parameters. Normally, only a small part of the shape parameters accounts for most of this variability, while the rest encode other types of variability, cause by pose changes or identity changes.

A problem which appears in general in face modeling is the robustness to different poses. As well as for full face modeling, the eyes model can be designed so that to include this kind of variability. If different poses are included in the training set, there will be a set of shape parameters which mainly account for pose variation. Thus, the shape model can be explicitly written as:

$$s = \bar{s} + \varphi_{blink} b_{blink} + \varphi_{pose} b_{pose} + \varphi_{shape_{of_{eye}}} b_{shape_{of_{eye}}}$$

where s is the shape model and $\bar{s}$ is the mean shape vector.

We tested the proposed model on The Essex Faces94 database [11] or on pictures taken especially for this study, containing different subjects with their eyes open or closed. The results showed promising, namely the model is able to locate the right parameters for identifying the correct state of the eyes and so to identify a possible blink.

III. SYSTEM OVERVIEW

We propose a robust, accurate algorithm to track the eyes and detect eye blinks. The method presented employs the AAM parameters information in order to recognize the

blinking. As exposed in Fig. 2, the eye detection is inferred from the Viola-Jones face detection algorithm [12], by using a statistical relation between the face parameters and the eye parameters taught from the training dataset.

In Fig. 3 we display an average over the shape parameters of the eyes model for two sets of images with eyes open and closed, respectively. It can be noticed that there is quite a clear differentiation between the two states of the eye in the first 8 to 10 parameters. Table I shows the tested performance of the proposed system.

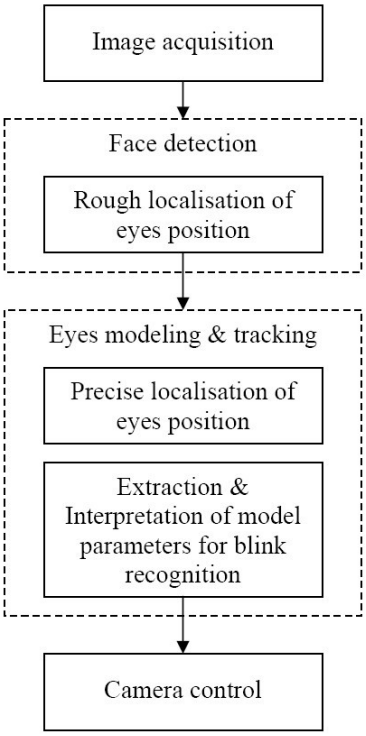

Fig. 2. System overview

IV.CONCLUSIONS

In this paper, we analyze the possibility of using AAM-based techniques to model the eye region area, in particular the visual process of eye blinking.

We proposed a straightforward proof-of-concept model, having as advantage that it models properly the eye region for both eyes open and closed and it can be fitted fast enough (up to real-time) to new images. An eye tracker and blink detector was also developed using this model.

Furthermore, we consider that our blinking model can be used in many applications like eye tracking robust to eye-blinking, or eye-closed warning in consumer-oriented digital imagery.

As future work we want to extend the technique so that to increase the robustness to eye gazing. The model could be expanded to a more sophisticated one, in order to include tracking of the iris/pupil.

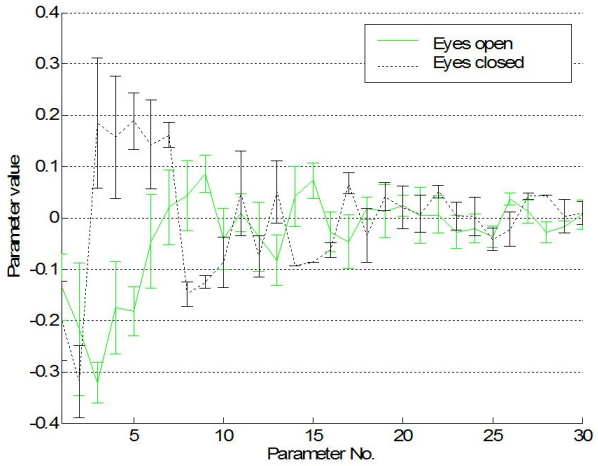

Fig. 3. Average values and the unit of standard deviation for the shape parameters tested on images with eyes open and closed, respectively.

TABLE I
SUMMARY OF RESULTS

System performance	
Eyes model fitting accuracy	95 %
Eyes tracking accuracy	98 %
Blink detection accuracy	94 %

References

[1] J. Orozco, J. Gonzàlez, P. Baiget, J. J. Villanueva, “Human Emotion Evaluation on Image Sequences ", in CogSys II Conference, Radboud University Nijmegen, Netherlands, April 2006.

[2] S. P. Lee, J. B. Badler, N. I. Badler, “Eyes alive”, in ACM Trans. Graph, vol. 21, no. 3, pp. 637-644, 2002.

[3] A.M. Tekalp, J. Ostermann, , "Face and 2-D mesh animation in MPEG-4", in Signal Processing: Image Communication, Vol. 15, pp. 387-421, 2000.

[4] T. Ishikawa, S. Baker, I. Matthews, T. Kanade, “ Passive Driver Gaze Tracking with Active Appearance Models”, Robotics Institute, Carnegie Mellon University, February 2004.

[5] M. Betke, J. Gips, P. Fleming, ” The Camera Mouse: Visual tracking of body features to provide computer access for people with severe disabilities”, IEEE Transactions on Neural Systems and Rehabilitation Engineering, March 2002.

[6] M. Chau, M. Betke, “Real Time Eye Tracking and Blink Detection with USB Cameras”, Boston University Computer Science Technical Report No. 2005-12.

[7] Ssontech SynthEyes: http://www.ssontech.com/

[8] Q. Ji , X. Yang, “Real Time Visual Cues Extraction for Monitoring Driver Vigilance”, ICVS '01: Proceedings of the Second International Workshop on Computer Vision Systems, pp. 107-124, 2001.

[9] T. F. Cootes, G. J. Edwards, and C. J. Taylor, “Active appearance models,” Lecture Notes in Computer Science, vol. 1407, pp. 484–, 1998

[10] D. W. Hansen, J. P. Hansen, M. Nielsen, A. S. Johansen, ” Eye Typing using Markov and Active Appearance Models”, WACV '02: Proceedings of the Sixth IEEE Workshop on Applications of Computer Vision, pp. 132, 2002.

[11] L. Spacek. The Essex Faces94 database. http://cswww.essex.ac.uk/mv/allfaces/.

[12] P. Viola, M. J. Jones, “Robust Real-Time Face Detection”, in Springer Netherlands for Computer Science, Volume 57, Number 2, May, 2004.